Doing Justice to the Future: a global index of intergenerational solidarity derived from national statistics

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by Jamie McQuilkin

Abstract: This paper proposes an index of national levels of "intergenerational solidarity", defined as "investments or sacrifices that are intended to increase or sustain the well-being of future generations".
This is measured by examining changes to the value and stability of various capital flows and stocks. Nine indicators are drawn from national-level statistics: forest degradation rate, share of low-carbon energy consumption, and carbon footprint in the environmental dimension; adjusted net savings, current account balance, and wealth in equality in the economic dimension; and primary pupil-teacher ratio, fertility rate, and GDP-adjusted child mortality in the social dimension.
This returns a comparative index score of intergenerational solidarity for 120 countries covering 92% of the world's population. Throughout, the state of the current research on intergenerational transfers and on the individual metrics used is discussed, and suggestions are made for further improvements and work in measuring intergenerational solidarity.
As it stands, the index provides the widest coverage of indicators and nations aimed at measuring any similar concept. As such, it is particularly useful for those who wish to investigate the causes of intergenerational solidarity through cross-cultural comparisons.

Keywords: *Intergenerational, Index, Intertemporal, Discounting, Long-term*

Editorial note: all supplementary material, consisting of descriptive statistics (Appendix I), some indicators considered for inclusion (Appendix II) and the full table of indicator and index scores (Appendix III) can be found on igjr.org.

Introduction[1]

"We act as we do because we can get away with it: future generations do not vote; they have no political or financial power; they cannot challenge our decisions." World Commission on Environment and Development (1987: 8)

For as long as societies have existed, we have saved, planned, bequeathed, and built for the future. As awareness has risen of the grievous long-term[2] consequences of some of our collective choices, there has been increased interest in quantifying and understanding intergenerational solidarity[3] (Oxford Martin Commission 2013).
Fortunately, in the last decades we have gained the national statistics and computational power to do this work. If we can first quantify and then find causes for variations in intergenerational allocations across cultures and institutions, we may be able to ensure that our own generations' legacy is more stable, just and sustainable.
This paper indexes intergenerational solidarity across 120 countries and 92% of the world's population, and begins to address this gap in the literature. The index includes nine variables, three each from economic, environmental and social dimensions, and aims to provide a common independent variable for those researching the causes of cross-cultural variations in intergenerational solidarity. Iterations of the index could also allow us to keep track of whether societies are (in theory) giving greater or less intergenerational solidarity from one year to another.
Anecdotally, it has long been said that the current generation discounts the future[4] to a greater extent than those before them. Laugier asserts:

> *"The ancients jealous of leaving to the latest posterity traces of their abilities, spared nothing in giving to their buildings that strength which triumphs over common accidents... Our artists have now-a-days none of that great taste of solidity. They doubt if their works can sustain the assault of three centuries. They are accused even of avoiding with design to render them lasting, because they are supposed interested to renew the labour of them. It is most certain that one often sees amongst our buildings quite new ones that threaten ruin."* (Laugier 1755: 129)

Are we, as Laugier says, becoming more short-termist? Are we thus heaping greater burdens on future generations? Are the reasons he suggests valid? This index is a first step to answering these questions.

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Conceptual framework
"Intergenerational justice" is a concept here defined as synonymous with "intergenerational equity". Defining what actually is "equitable" is impossible to do *a priori* in the context of future generations, who are silent in their preferences, of an unknown number, and of unknown means. Nonetheless, this does not prevent us from comparing intergenerational allocations, here set in the context of intergenerational solidarity.
"Intergenerational solidarity" does not yet have a standardised definition. Until the Rio+20 conference, "intergenerational" usually meant "between old and young generations" (World Future Council 2013). Here, as in current sustainability usage, intergenerational solidarity "goes beyond relations among the currently living representatives of different generations to embrace the future generations who do not yet exist" (United Nations 2013). "Solidarity" in this context can be approximated by "intentional actions that increases or sustains wellbeing" (see Lopes 2015) usually involving "sacrifices and investments" (United Nations 2013).

Thus, the working definition of "intergenerational solidarity" for this paper might be "investments or sacrifices that are intended to increase or sustain the wellbeing of future generations". This can be said to be the means by which we carry out our impression of what is intergenerationally just.[5]

Criteria for selection

The criteria for selecting indicators (after Hsu et al. 2013; OECD 2008) are as follows:

Theoretical relevance. Indicators must have a strong conceptual relationship to intergenerational resource allocation and to human wellbeing.

Coverage. The index must cover >100 national entities containing >90% of the world's population, and its range must be such that it is able to distinguish countries in a meaningful way.

Comprehensiveness. The index must include indicators relating to economic, environmental and social spheres in equal measure. Each metric must not have disproportionate influence over the total index. Few or no indicators should be missing for any country.

Transparency. The number of indicators should be concise, and assumptions, sources and transformations should be clear. The index should avoid a "black box" approach.

Source Quality. Sources must be respected, use standardised collection methods and provide open access.

Future-proof. There must be an on-going commitment from source institutions to regularly update indicator data.

> Are we, as Laugier says, becoming more short-termist? Are we thus heaping greater burdens on future generations?

National accounts are the level of analysis for a practical reason: reliable and comparable data simply do not or cannot yet exist for measuring intergenerational solidarity of component parts of society, such as companies, civil society organisations, individuals or governments.

However, it seems reasonable that national statistics may have a bias towards revealing of the priorities of governments, although they will also be affected by the choices of individuals and institutions. It is also often assumed that part of the duty of government, in the implicit[6] social contract that legitimates them, is to work for the *demos* of today and the future – this is less so for other parts of society.

Similar existing work

Little work has been done to construct cross-cultural indexes of intergenerational solidarity or similar measures, especially outside of the OECD. In a paper correlating cultural values and long-termist policy, Kasser (2011) used advertising to children, CO_2 emissions, parental leave and child wellbeing. Elsewhere, Vanhuysse (2013) used a figure of public debt per child, ecological footprint and age-based differences in poverty to compile an "Intergeneration Justice Index". Also, Noguchi et al. (2014) used Google searches for future years as an indicator of national future orientation.

Kasser's work is an example of where this index can be useful, as a framework for researchers in disparate fields looking to correlate their own dependent variables (cultural values in his case) with intergenerational solidarity.

In the sustainability literature, there are a vast array of composite indexes (for a review of some, see Singh et al. 2012; Stiglitz et al. 2009) but almost all do not focus on the future. One exception is the World Bank's Adjusted Net Savings (ANS; included in this paper; see the section on Economic Indicators for more details). This is the best-known attempt at a comprehensive economic measure of changes in capital stocks, and includes measures of environmental and human capital. Unfortunately, its assumptions and ethical framework are dubious (Thiry/Cassiers 2010); the most important objection is that, as with other indicators of "weak" sustainability (Pierce/Atkinson 1993), it is over-simplistic in its assumption that all value can be adequately reduced into fungible dimensions denominated in dollars.

On the other hand, the Index of Economic Wellbeing (Osberg/Sharpe 2002) does have a similar aim but does not quantify everything in dollars. Its other dimensions are interesting – particularly the "economic security" dimension which addresses risks rather than value – but the datasets the authors use only exist for a fraction of OECD countries.

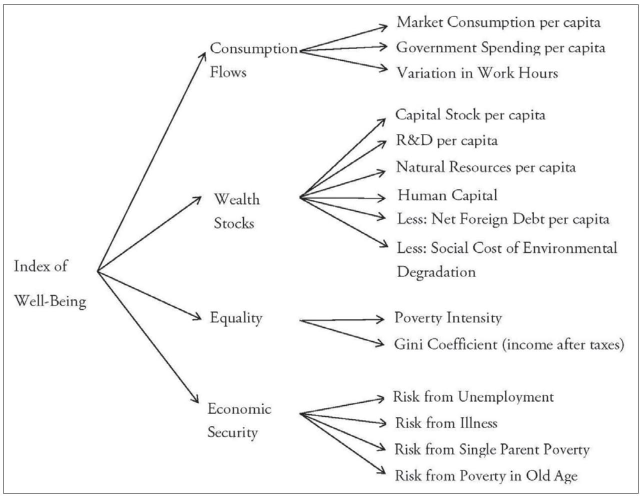

Figure 1: Index of Economic Wellbeing weighting tree (Osberg/Sharpe 2002)

Environmental indexes (e.g. Hsu et al. 2014) often measure effects over the long term, but differences in time horizons are rarely acknowledged. For instance, radioactive pollution is a significant issue for future generations, whereas particulate pollution is largely not. CO_2-equivalent greenhouse gas indexes are a notable exception; global warming potential is usually explicitly calculated over 100-year time horizons (Shine 2009), so as to adjust the impacts of e.g. short-lived methane vs. long-lived carbon dioxide.

Method

Operationalising "intergenerational solidarity"

Intergenerational solidarity's "investments or sacrifices" can be expressed in terms of change to the value and stability of various kinds of non-substitutable[7] inherited capital. Capital encompasses a society's "manufactured capital, human capital, natural capital, and knowledge, but also its institutions" (Dasgupta 2001: 142). Stability implies *resilience*, "the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks"; *adaptability*, "the capacity of actors in a system to influence resilience"; and *transformability*, "the capacity to create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable" (Walker et al. 2004). For example, building a house with intergenerational solidarity in mind might mean building a sturdy, useful, low-impact structure (i.e. with high capital value) that is designed to be flexible to different uses (resilient), easily repairable and adjustable (adaptable), and might be recycled at the end of its useful life (transformable).

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However, although they are crucial to intergenerational solidarity, parameters of stability are highly specific to whatever individual system they refer to, and it is not possible to measure them on aggregate at a national level.[8] Instead, in this index they are discussed when they relate to other indicators.

The index aims to measure proportional solidarity: from each nation according to its ability to give. However, the poorest nations must prioritise survival needs above all, something reflected in the generally high social discount rates set by governments of developing countries (Zhuang et al. 2007).

Selecting indicators

A longlist of candidates was selected and winnowed.[9] Nine indicators were chosen in sets of three, each primarily focused on economic, environmental or social dimensions. This number allows for simplicity whilst ensuring that no one indicator had disproportionate influence. All of the indicators are likely to be proxies of several kinds of capital, but were grouped according to their primary focus.

It should go without saying that this index is not intended to be precise or comprehensive, but rather a working yardstick for an otherwise unmeasurable composite construct. In the aim to make an index with wide coverage of countries, it is also inevitable that indicators will be excluded that would otherwise give greater precision.

Normalising and aggregating indicators

After selection, the indicators were normalised to a common range of 0-100. The boundaries were set based on the boundaries of the original range or on benchmarks based on literature or data distribution. The goal of normalising the indicators was to give thresholds, not targets. For example, in the indicator of forest degradation, "zero net loss" is the benchmark for 100. Net gain may or may not indicate intergenerational solidarity, but here is not given more "credit" than zero net loss. To give another example, the upper bound for primary pupil-to-teacher ratio was set at 10:1 and the bottom at 50:1 purely from data distribution; prescriptive targets for this indicator simply do not exist.

Importantly, this means that scores on indicators (and thus the index) only make sense in terms of comparisons between countries. Where noted, some indicators were normalised for population or GDP (with purchasing power parity) or transformed to give greater weight to relatively small differences or to cluster extreme differences. The standard equation used was:

$$100 \left(\frac{\textit{Observed value} - \textit{minimum}}{\textit{Target} - \textit{minimum}} \right)$$

which is a variant of that used in the Environmental Performance Index (Hsu et al. 2013) and the Human Development Index (UNDP 2014). Details are given where this was modified.

Most indicators averaged the most recent available data (following the method of Vanhuysse 2013), over the most recent five years – a common policy timeframe – to smooth fluctuations. However, countries were not excluded if some years used in the average were missing.

All indicators have equal weight but are aggregated geometrically following the method of the Human Development Index (UNDP 2014). Equal weighting is common in composite indexes (Böhringer/Jochem 2007), particularly in the absence of clear theory on their relative importance.

> Intergenerational solidarity only has meaning in terms of an aggregate of its component parts.

Geometric aggregation takes the following form, with indicator scores represented by *i* and the number of indicators *n*:

$$(i_1 \times i_2 \ldots \times i_n)^{\frac{1}{n}}$$

Geometric aggregation, while more difficult to communicate than linear aggregation, partially rectifies the problem of the unsubstitutability of capital stocks and flows (Hsu et al. 2013). It ensures that high scores in the index should reflect a high score in most of the indicators, rather than particular excellence in a few areas, and that low scores are disproportionately penalised (Böhringer/Jochem 2007; Ebert/Welsch 2004), suiting it to indexes aggregating radically different dimensions (OECD 2008; UNDP 2010).

It also means that more critical attention should be paid to the assumptions behind benchmarks and transformations. For instance, one extremely low indicator will have a significant effect on the final score: even if eight indicators score 100, if the last scores one[10] then the index will only give a total score of 60.

There is a long-running debate in sustainability literature about the dangers inherent in aggregating indicators (OECD 2008). However, intergenerational solidarity only has meaning in terms of an aggregate of its component parts. As Stiglitz et al. put it, "composite indicators are better regarded as invitations to look more closely at the various components that underlie them" (Stiglitz et al. 2009: 65).

Environmental Indicators

To be in solidarity with future generations, today's generations must curtail pollution and ecological degradation and ensure that resources are used with an eye to limits. Specifically, greenhouse gas emissions, soil degradation, biodiversity loss and nutrient pollution appear to be the issues with greatest cause for global alarm (Bindraban et al. 2012; Steffen et al. 2015). Unfortunately, there are only national accounts of greenhouse gas emissions, due to measurement difficulties. However, the three indicators chosen for the index – forest degradation, carbon footprint and low-carbon energy use – can be considered proxies for soil degradation and biodiversity loss inasmuch as these are exacerbated by climate change (Nearing et al. 2004; Thomas et al. 2004) or are caused by deforestation (Maina et al. 2013; Mendenhall et al. 2012; Siikamäki/Newbold 2012).

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Forest degradation is the only indicator with missing data for some countries, due to lack of forest cover. To compensate, in these instances the weighting of the other two environmental indicators was increased from 1/9 to 1/6, in order to preserve equality of contribution from each dimension.

Environmental Indicator: Net forest degradation

The indicator

Satellite data for forest density in 30m² blocks were used (Hansen et al. 2013b) because of the much greater accuracy of that database over UN FAO self-report data (UNFAO 2014, see Hansen et al. 2013a). A twelve-year average was used based on the limited data currently published, to which the authors have guaranteed regular updates. Only forest of >50% canopy was used because of limitations on forest gain data, and 19 countries with <200km² of this were excluded, after the EPI method (Hsu et al. 2014).

Metric	0	100	Equation[11]	Time period	Source
Net change in forest with >50% canopy cover	≤-10%	≥0%	$100\,\frac{x-(-10)}{0-(-10)}$	12-year average (2000-2012)	Hansen et al. (2013a)

Table 1: Equation, definition and data source for net forest degradation indicator

10% annual loss was used as a lower benchmark as the worst performer's loss rate of 16.8% was extreme (Figure 2). Zero net loss was the upper benchmark as the afforestation of some nations is ecologically questionable (e.g. see Geary 2001 for discussion of Uruguay's 22% increase). Only 10 of 120 included nations achieved zero net loss.

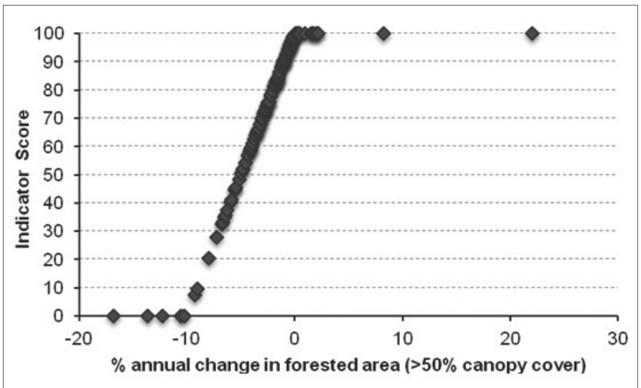

Figure 2: Relationship between forest degradation indicator scores and annual forest loss

Theoretical basis

"The diligent farmer plants trees of which he will never taste the fruit" (arbores seret diligens agricola, quarum aspiciet bacam ipse nunquam)
– Cicero in *Tusculanae Disputationes*, c.45 BCE

Forest husbandry is inherently a long-termist enterprise, whether by preservation or active plantation. For example, in an extraordinary continuous act of intergenerational solidarity, peasant coppice foresters in 2nd-millenium European countries would often rotate coppice-with-standards on regular cycles of 30 years for the coppice understorey, and up to 160 years for the overstorey that grew above them (Short/Hawe 2012). It also seems plausible that a country that conserves its trees may protect other ecosystems.
However, the indicator is not sensitive to the fine-grain forest ecology. Will future generations prefer diverse old-growth forest ecosystems, or relatively barren reforested but economically-preferable Sitka spruce plantation as is common in Europe (Magura et al. 2002)? Or would they prefer an ecologically-sensitive agroforestry regime to any of these, something classed as "degraded forest" here?
Lastly, trees do not just fall to chainsaws – they are also affected by storms, climate change, fire, disease, drought and a number of other factors (Le et al. 2012). Notable instances of this are cyclone damage in Sweden (4.1% annual net loss – see Valinger/Fridman 2011), and beetle plagues in Canada (3.7% loss – see Kurz et al. 2008). Nonetheless, it is quite clear that humans are driving the degradation in most countries (Hansen et al. 2013a).

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Future directions

Some countries are reducing degradation rate substantially – for example, Brazil's loss in 2011 was over two-thirds less than the 1996-2005 average by one measure (Boucher et al. 2011). When annual data are available, it may be better to look at a predicted long-term trend in degradation rate. It may also be possible to control for natural causes of degradation discussed above. Also, once satellite data on forest gain of <50% canopy cover exist, it may be preferable to differentiate clear-felling from degradation.

Environmental Indicator: Carbon footprint (consumption-based)

Metric	0	100	Equation	Time period	Source
Carbon footprint component of ecological footprint	Undefined	≤ 0.6 Global hectares per capita (Gha/c)	$100 \cdot \frac{0.6}{x}$	2011	Global Footprint Network (2015)

Table 2: Equation, definition and data source for consumption-based carbon footprint indicator

The indicator

The consumption-based carbon footprint is a component of the ecological footprint. All data come from the 2011 dataset (Global Footprint Network 2015) except for Iceland's, which was estimated to be the same as Norway's because of similarities in consumption patterns, consumer imports and renewable energy production.

The world's average carbon footprint was estimated to be 1.4 global hectares per capita (Gha/c) in 2009, and average ecological footprint 2.6 Gha/c. The world's biocapacity was estimated at 1.8 Gha/c. Assuming that most of this 0.8 Gha/c reduction must come from carbon emissions, the target carbon footprint should be 0.6 Gha/c. This target is consistent with the data: Algeria, Ecuador, Guatemala and Jamaica all have ecological footprints of 1.8 Gha/c and have carbon emissions of 0.5-0.8 Gha/c.
A simple reciprocal transformation was used to adjust the scale, meaning that doubling footprint halves the indicator value – i.e. 1.2 Gha/c = 50, and 2.4 Gha = 25.

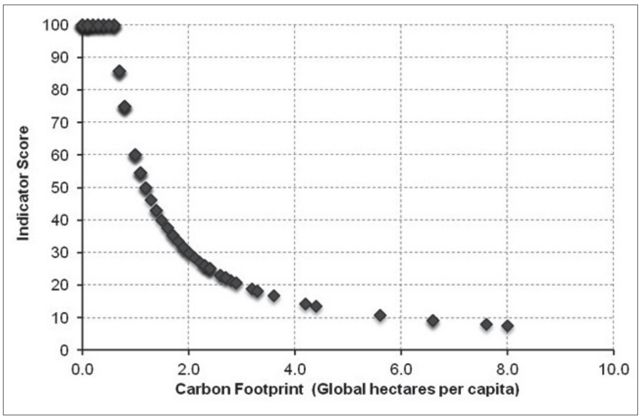

Figure 3: Relationship between carbon footprint and indicator scores

Theoretical basis
The benefits of emitting greenhouse gases are frontloaded and severe damage is back-loaded over thousands of years (Solomon et al. 2009). It also is the only part of the ecological footprint which can go into "debt"; i.e. the other components cannot by definition exceed the earth's biocapacity. There is also a general consensus that it is more useful than the greater ecological footprint measure (Stiglitz et al. 2009: 71, 80).

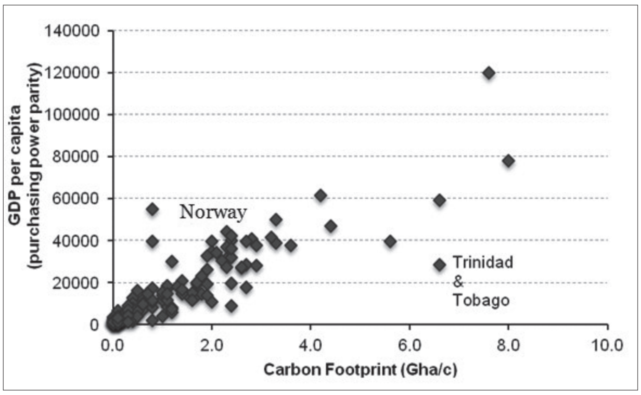

Figure 4: GDP and carbon footprint (2011 data)

Consumption-based emissions implicitly assign greater responsibility to consumers to reduce consumption or demand better efficiency, which is often justified by the current economic inequality between consumers and producers. However, it should be noted that currently, many low per-capita CO_2 emissions are often not due to intergenerational solidarity but rather a sign of poverty (Figure 4).

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Future directions
It might be argued that this indicator should be corrected for GDP, not done here to preserve simplicity. In particular, a "carbon intensity" (Davis/Caldeira 2010) correction of the following form was considered:

$$(i_1\times i_2 \ldots \times i_n)\,\frac{1}{n}$$

where G is GDP/c and current footprint (*x*) was set at a minimum of 0.6 Gha/c to emphasise the need for economic development. This formula would, in a rough way,[12] measure how much GDP is generated within the quota of 0.6 Gha/c and rank countries accordingly.

Environmental Indicator: Low-carbon energy generation

Metric	0	100	Equation	Time period	Source
Low-CO_2 energy generation as % of total consumption.	=0%	=100%	$100\sqrt{\frac{x-0}{100-0}}$	5-year Average (2007-2011)	International Energy Agency (IEA, 2015a) and U.S Energy Information Administration (US EIA, 2014)[13]

Table 3: Equation, definition and data source for low-carbon energy use indicator

The indicator
This indicator measures energy use from minimal-CO_2 energy sources such as geothermal, hydroelectric, nuclear, wind and solar. It excludes biofuels such as sugarcane or corn ethanol. A square-root transformation (Figure 5) was applied for reasons explored below.

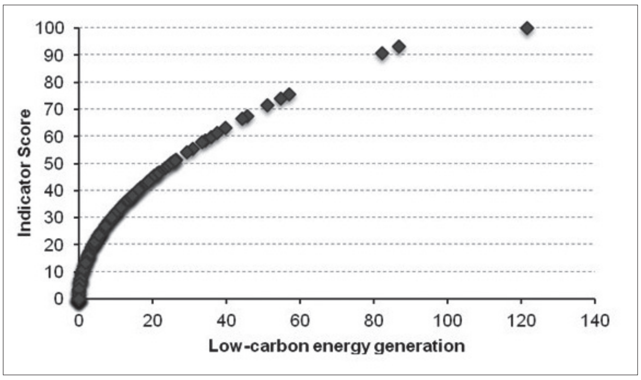

Figure 5: Relationship between low-carbon energy generation indicator scores and low-carbon energy generation, including for export

Theoretical basis
Fossil fuel use makes up a large part of most nations' CO_2e emissions (e.g. c.79% for the USA in 2013 – US Environmental Protection Agency 2015) and the high cost and long life-

times of its infrastructure entails formidable path dependency. Given the urgent need for drastic decarbonisation of energy generation, current low-carbon energy use improves the wellbeing of future generations not only through emitting less CO_2, but also through not deferring the cost of investing in low-carbon infrastructure.

Much has been said about long-term planning of nuclear waste disposal (and lack thereof), but nuclear energy remains one of the most long-term-oriented enterprises that industrial civilisation undertakes. A plant lifecycle may be 100 years, and fuel disposal must plan for radioactive isotopes with half-lives of millennia.

Nuclear fuel is non-renewable, but including it adds a particularly long-term component to this indicator, given its vital current role in decarbonising energy generation. Much has been said about long-term planning of nuclear waste disposal (and lack thereof), but nuclear energy remains one of the most long-term-oriented enterprises that industrial civilisation undertakes. A plant lifecycle may be 100 years, and fuel disposal must plan for radioactive isotopes with half-lives of millennia. For example, the Onkalo deep geological repository in Finland is midway through an 80-year design, operation and decommissioning cycle and is expected to safely store nuclear waste for 10,000 years (Nummi et al. 2012: 38).

It should also be noted that a very high score is often due to a combination of easy availability of hydroelectric dam sites and low populations rather than long-term planning. Particular examples of this are Norway, Paraguay, Iceland (also geothermal) and Tajikistan. In order to elevate the scores of less favoured countries that still invest in the long term, a square root transformation was applied.

Future directions

An assessment of the sustainability of biofuels and household waste might significantly improve the accuracy of the indicator in some countries. For example, in Brazil 22.9% of energy consumption in 2012 came from biofuels (IEA 2015b). However, sufficient source data and precise theory on the sustainability of biofuels are currently lacking.

It may also be possible to adjust for the CO_2e impact of renewables, for example from the titanic quantities of cement used in some hydroelectric dams and the vast quantities of methane released from tropical reservoirs. Currently, however, there is too much uncertainty about lifecycle analyses of both this and biofuels for them to be taken into account (Johnson 2009; Liska et al. 2014; Melillo et al. 2009).

Economic Indicators

Increasing the wealth of nations is critical for future welfare, yet current policy is often focused on optimising production, rather than the sustainability or division of future wealth (Stiglitz et al. 2009). In order to address these issues, the economic dimension includes the adjusted annual amount of product saved, the sustainability of current investment, and the distribution of wealth.

The central government social discount rate used in calculating cost-benefit analyses is unfortunately omitted here. Despite its importance to intergenerational projects and particularly to climate change mitigation and adaptation, many countries have no available social discount rate or different rates between departments (Zhuang et al. 2007). Currently, its use is worryingly arbitrary; Moore et al. (2004) memorably characterise policy-makers as demanding that economists "just give me a number!"

Economic Indicator: Adjusted Net Savings

Metric	0	100	Equation	Time period	Source
% of GNI, 5-year average	≤0%	≥20%	$100\left(\frac{x-0}{20-0}\right)$	5-year average (2008-2012)	World Bank, (2015)

Table 4: Equation, definition and data source for Adjusted Net Savings indicator

The indicator

Adjusted Net Savings (ANS) is an attempt at a catch-all indicator for "sustainable investment". It is calculated by taking gross savings (itself made up of gross capital formation, net capital inflows and changes in foreign reserves) and subtracting estimated resource depletion, emissions damages from particulates and CO_2, and consumption of fixed capital, and adding public spending on education (Figure 6). The World Bank calls it an indicator of a broadly-defined "weak sustainability" (Bolt et al. 2002) that assumes substitutability of different kinds of capital.

The economic dimension includes the adjusted annual amount of product saved, the sustainability of current investment, and the distribution of wealth.

Adjusted Net Savings is currently the most comprehensive dollar-equivalent index of changes in capital, covering 173 nations and groupings. It was normalised in the range 0-20% of GNI based on data distribution (Figure 7).

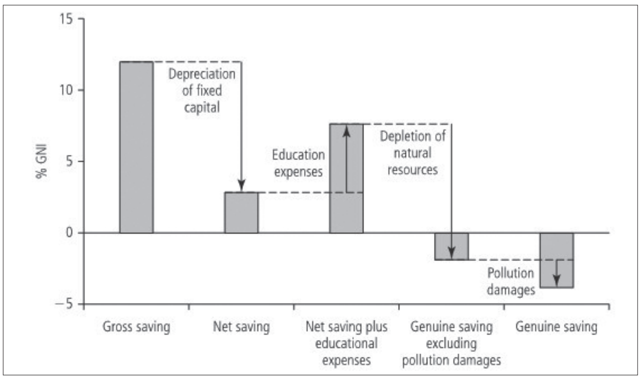

Figure 6: Calculating Adjusted Net Savings (World Bank 2006)

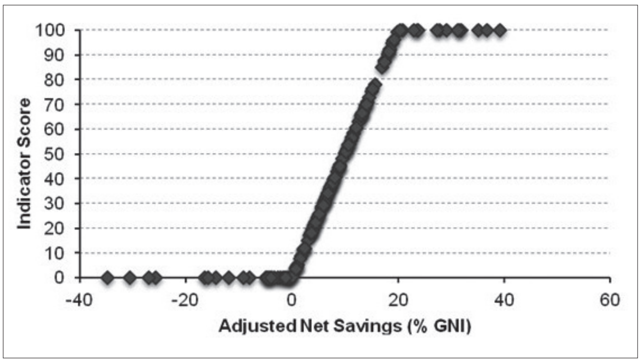

Figure 7: Relationship between ANS indicator score and ANS

Theoretical basis

That Adjusted Net Savings essentially measures consumption deferred to the future. However, ANS has been robustly criticised, amongst other reasons for assumptions of substitutability of capital, production-based responsibility for pollution, market valuing of resources and so on – see Pillarisetti (2005) and Thiry/Cassiers (2010) for summaries. It also seems to have only a weak relationship to other indicators that might be considered to be proxies for the wellbeing of future generations, e.g. infant mortality and Human Development Index (Gnègnè 2009). Following Stiglitz et al. (2009), it seems best to treat it as a measure of savings of solely economic wealth; we should not forget John Ruskin's caution that "that which seems to be wealth may in verity be only the gilded index of far reaching ruin" (Ruskin 1872: 52).

Future directions

ANS may be superseded by more comprehensive indexes with similar aims such as the Inclusive Wealth Index (UNU-IHDP/UNEO 2014). However, this also has poor assumptions, such as an economic valuation of human life proportionate to GDP per capita, with the consequence that an African's life is "worth" less than a European's.

Economic Indicator: Current account balance

Metric	0	100	Equation	Time period	Source
Current account balance (% of GDP)	≤-10%	≥0%	$100\left(\frac{x-(-10)}{0-(-10)}\right)$	5-year average (2009-2013)	International Monetary Fund (IMF, 2015)

Table 5: Equation, definition and data source for current account balance indicator

The indicator

The current account quantifies the balance of flows of goods and services in and out of a national economy, as well as investment income and unreciprocated transfers (e.g. international aid and remittances). Simplistically, a deficit in the current account must be met by selling assets or foreign borrowing. Cut-offs were based on theoretic concerns as described below, and no transformation was applied (Figure 8).

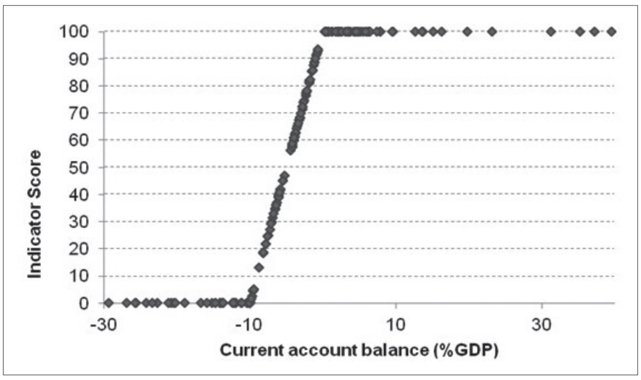

Figure 8: Relationship between current account balance indicator scores and current account balance

Theoretical basis

Current account deficits directly affect capital transfer to future generations. Today's deficits require matching future surpluses financed by exports, higher savings or lower investment (Olivei 2000); another description of these patterns is "intertemporal trade" (Corden 2011; Leimbach/Baumstark 2011).

A deficit is not necessarily bad if the foreign investment potential outweighs the costs of incurring debt or selling assets (Blanchard/Milesi-Ferreti 2012), but even "good" deficits mean borrowing or selling assets against future income and are risky (Obstfeld 2012), potentially making whole economies less resilient. This has been shown many times in massive investment failures in developing countries, and capital flight as a result of asset bubbles (Edwards 2004).

A deficit is not necessarily bad if the foreign investment potential outweighs the costs of incurring debt or selling assets, but even "good" deficits mean borrowing or selling assets against future income and are risky, potentially making whole economies less resilient.

While there is a consensus that significant current account deficits are "bad" because they imply instability (Boljanović 2012; Edwards 2004), it is difficult to be precise in giving a range to this indicator. A lower bound of -10% of GDP can be justified by risk, looking at the current account deficits that predicated various capital flight[14] crises and the economic performance of countries in the Eurozone in the last 10 years.[15] For example, immediately before their crisis in 1997, the South East Asian economies had deficits of between 2% and 8% (Radelet/Sachs 1998), and a 5% current account deficit is generally considered to be problematic (Boljanović 2012).

The upper bound is not higher than 0% (no net "intertemporal trading") because current account surpluses, while often good for future wellbeing in individual nations, are sometimes damaging to the nation (Blanchard/Milesi-Ferreti 2012) and imply a deficit in other countries.

Future directions

A more refined metric might disaggregate the causes of current account deficits (e.g. differentiate consumption binges from development aid), which can determine to a great extent whether they cause crises (Milesi-Ferretti et al. 1996). It might also penalise countries, particularly those with above-average GDP, which have excessive surpluses in the long term without a good cause (e.g. Germany). More work should also be done to examine the multi-decadal current account deficits of the USA, UK and others – in the argument of "monetary hegemony", these countries may be able to sustain long-term deficits with few ill effects as an effect of demand created by their currencies being used as international reserves.

Economic Indicator: Wealth inequality

Metric	0	100	Equation	Time period	Source
Gini coefficient of wealth inequality	=1	= 0	$100-100\left(\frac{(x-1)+1}{0-1}\right)^2$	2014	Stierli, Shorrocks, Davies, Lluberas, & Koutsoukis (2014)

Table 6: Equation, definition and data source for wealth inequality indicator

The indicator

National wealth data including its Gini coefficient are not collected by any intergovernmental agency with coverage larger than the OECD, but are currently estimated annually by Crédit Suisse. Crédit Suisse are widely respected, use a transparent method (Shorrocks et al. 2014) and give quality ratings for the estimations for each country. Their definition of wealth includes financial assets, housing and land; liabilities are subtracted; and their analysis applies to adult individuals (i.e. not households) aged over 20.

Given economic growth is finite, future poverty reduction will mean wealth redistribution. Also, it seems reasonable that equal wealth distribution indicates long-term social planning and strong institutions, as it requires strong redistributive institutions and takes time to implement.

The equation for this indicator includes a square transformation which has been inverted and shifted towards the y axis. Superficially similar to a logarithmic transformation, it gives a steeper gradient in mid-values for improved differentiation.

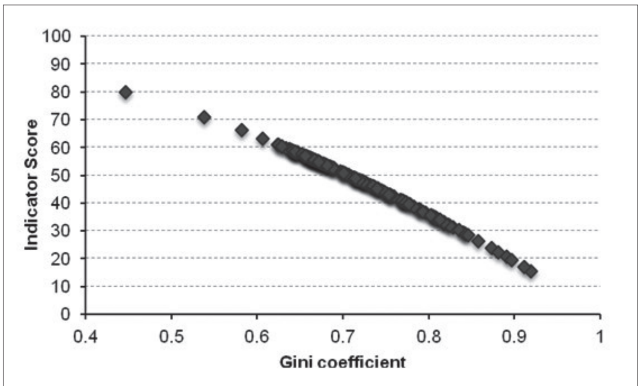

Figure 9: Relationship between wealth inequality indicator scores and wealth-Gini coefficient

Theoretical basis

The inclusion of this indicator rests on an ethical argument about the inheritance of future generations, based on the well-known "veil of ignorance" theory (Rawls 1999) of morality and a widely-held belief that wealth can give wellbeing only if it is equally or meritocratically distributed (Piketty 2014). Given that economic growth is finite, future poverty reduction will mean wealth redistribution (Daly 1990). Also, it seems reasonable that equal wealth distribution indicates long-term social planning and strong institutions, as it requires strong redistributive institutions and takes time to implement.

While wealth data are noisier than income data, the relative persistence of wealth inequality, its causative role in persistent income inequality and its greater importance to wellbeing and illbeing (particularly regarding security) prioritises its inclusion (Carter/Barrett 2006; Headey/Wooden 2004; Kuypers/Marx 2016; Piketty 2015; Ruberton et al. 2016). Wealth also plays a smoothing role in household economies through reducing uncertainty, which may be more relevant to rates of intertemporal savings than average income itself (Sørensen 2013).

A Gini index of 0 is unachievable and may also be undesirable within the current economic framework; there are likely to be diminishing returns to wellbeing below a certain level. However, given the absence of an empirically-derived "ideal" value of wealth inequality, it is used as an upper bound.

The social dimension of sustainability is notoriously difficult to define, and has been characterised as "a concept in chaos" (Vallance et al. 2011: 342).

Future directions

Measurements of household wealth are still in their infancy. The method and data for this indicator should be given particular scrutiny in future updates, and it may be possible to take account of different levels of public provision of e.g. housing, health and education that can lessen the effects of inequalities in private wealth. The range for the indicator might also be adjusted based on theory.

As data resolution and coverage continue to improve, it may be feasible to incorporate data sources with more robust methods (e.g. Alvaredo et al. 2017) or specific components, such as the share of public wealth. Also, incorporating work on the relationship between wealth and time discounting may strengthen the conceptual foundation of this indicator.

Social Indicators

The social dimension of sustainability is notoriously difficult to define, and has been characterised as "a concept in chaos" (Vallance et al. 2011: 342). Here, the indicators measure the inheritance of human capital in the form of education and health, but it seems that indicators of future social capital do not exist.[16] As a compromise, an adjusted fertility rate is used as an indicator of social capital, with the argument that too-high and too-low rates may predict difficulties for social institutions.

Social Indicator: Primary pupil-teacher ratio

Metric	0	100	Equation	Time period	Source
Pupil-teacher ratio in public primary schools	50:1	10:1	$100\left(\frac{50-x}{50-10}\right)$	10-year average (2002-2012)	UNESCO (2015) and ACARA (2011, 2013); Agency for Statistics of Bosnia and Herzegovina (2011); Lomborg (2009); OECD (2014); Wolff (2008)

Table 7: Equation, definition and data source for primary pupil-teacher indicator

The indicator

This indicator measures the number of teachers for every pupil in publicly-funded primary education (UNESCO 2012). Due to poor collection, some countries have only one data point in the last 10 years, hence the long average. It should also be noted that this indicator is not the same as class size.

Due to lack of conclusive targets in the literature, the indicator benchmarks were based mostly on a subjective assessment of data distribution, with no transformation. Only three countries in the index (Iceland, Sweden and Norway) had better ratios than 10:1, and only 10 nations had ratios greater than 50:1, ranging up to 76:1 for Malawi (Figure 10). "Large class size" is also sometimes defined as >50:1 (Jin/Cortazzi 1998; Qiang/Ning 2011);

Krueger (2011) found improved results for class size at least down to 15:1.

> The indicators measure the inheritance of human capital in the form of education and health, but it seems that indicators of future social capital do not exist.

Changes in the values of the benchmarks were also analysed to ensure that overall index results were not sensitive to them; e.g. a lower boundary of 60:1 would affect index scores by <1 point on average, and change rankings by an average of 2 places, with very little effects on the countries at the top of the rankings.

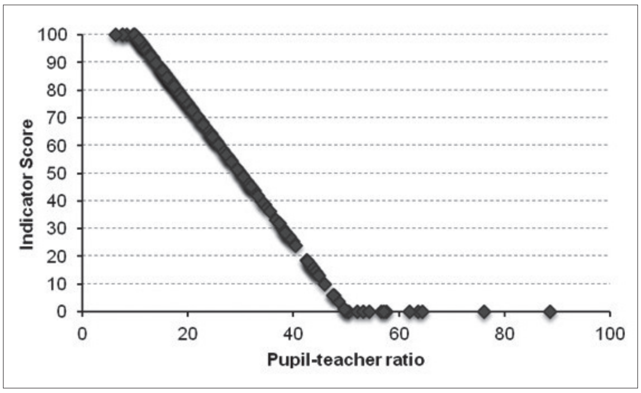

Figure 10: Relationship between pupil-teacher ratio indicator score and pupil-teacher ratio

Theoretical basis

"To plan one year ahead, plant grains. (一年之計，莫如樹穀) *To plan ten years ahead, plant trees.* (十年之計，莫如樹木) *To plan a lifespan ahead, plant people.* (終身之計，莫如樹人)"
- Guan Zhong (管仲) and other scholars as quoted in the Guanzi (管子), 7th to 4th century BCE

Primary education was specifically chosen because it is an investment in the wellbeing of future generations that is not likely to directly benefit current generations for 10-20 years at least. Also, as the Secretary-General of the United Nations put it:

> *"Education is itself critical to intergenerational solidarity as the means of transmitting accumulated, or at least the most recent, scientific and other knowledge to future generations."* (United Nations 2013: 8)

Regardless of educational outcomes, it is also indicative of a more general societal willingness to trade off current wellbeing (money spent on teachers' salary[17]) for others in the future (Kasser 2011). Secondary and particularly tertiary education were excluded because they are less comparable between countries because of greater differences in public and private education models, and because they are more directly linked to the economic interests of current generations.

Future directions

In some nations with pyramidal demographic structures, a high pupil-teacher ratio may not be caused by lower prioritisation of education, but instead purely by the ratio of children to adults. It may be possible to correct for this. A priority for this indicator should be to incorporate research into the differential effects of the pupil-teacher ratio on educational achievement, as it seems quite unlikely that there is a purely linear effect.

Social Indicator: Fertility rate

Metric	0	100	Equation	Time period	Source
Predicted number of children per woman in five years projected using a five-year average (x), corrected for child (<5 years) mortality (y)	n/a	1.8	$100\left(\frac{1.8}{1.8+\sqrt{(1.8-x)^2}}\right)^2 \cdot y$	5-year prediction (2017) based on 5-year regression (2008-2012)	World Bank, (2015b)

Table 8: Equation, definition and data source for fertility rate indicator

The indicator

This indicator measures the predicted fertility rate using a linear extrapolation of the trend of the last five years, in order to measure policy as opposed to current status. Countries where the regression coefficient for the previous five years was ≤0.5 were instead predicted using the average of the last five years. The indicator score is calculated using the formula above, giving a representation of "distance from the optimum", either positive or negative (Figure 11). The square of the full fraction was added to address the fact that population does not grow or shrink linearly and small differences make large effects; if left unsquared, a fertility rate of 7.2 would score 25 despite being socially problematic.

> A shrinking population might sometimes be beneficial, implying that absolute GDP, footprint and so on may be reduced while maintaining or increasing GDP per capita. However, too much reduction [...] may also result in so-called "government of the elderly, by the elderly and for the elderly" as in Japan.

The selected optimum value of 1.8 is theoretically based on an assumed replacement-level fertility of 2.1, and explained further below. The figure of 2.1 is below replacement for countries with significant mortality rates before menopause (Espenshade et al. 2003). As a partial correction for this, fertility rates were multiplied by the fraction of children surviving to five years; data for later pre-fertility years could not be currently obtained.

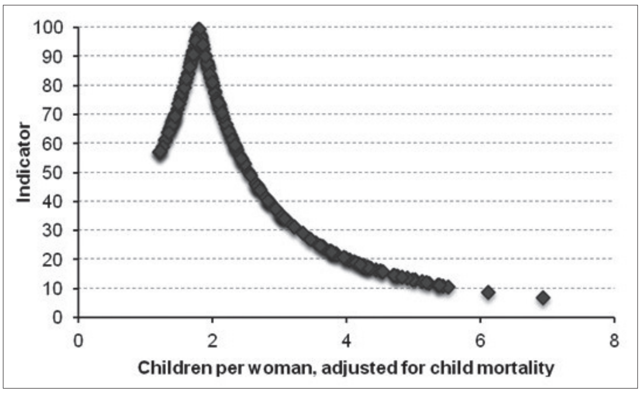

Figure 11: Relationship between fertility rate indicator and adjusted fertility rate

Theoretical basis

Population growth and decline is an emotive and controversial subject that has often been simplistically addressed in economics and sustainability literature. However, there are several arguments for its inclusion in a measure of intergenerational solidarity.

First, as is noted in the I=f(P,A,T)[18] equation (Alcott 2010), a rising population may increase impact on the environment. This applies most in the richest countries, as the majority of growth in developing nations comes from the families with the lowest footprints (Aassve et al. 2005). However, in these nations it may imply increasing inequality, expansion of slums and pressure on social institutions (Davis 2006). Population growth may also negatively affect future wellbeing through reduction in share of scarce resources such as water.

A shrinking population might sometimes be beneficial, implying that absolute GDP, footprint and so on may be reduced while maintaining or increasing GDP per capita. However, too much reduction at once means that few young people are left to care for elderly dependents. This is especially so if, as in many developed countries, lifespans have increased but pensioning ages have not. It may also result in so-called "government of the elderly, by the elderly and for the elderly" as in Japan (Coulmas 2007: 92).

On balance, it seems prudent for countries to aim for fertility rates of less than replacement, but not too low. The "optimum" of 1.8 was chosen conservatively based on figures tentatively suggested by demographers Striessnig and Lutz (2014) in research involving thousands of simulated populations. They state "longer-term fertility levels somewhere between 1.5 and 1.8 are the best for our planet and will, at the same time, result in future higher welfare as long as we invest more in… education."

<u>Future directions</u>

It is preferable to correct for differences in the death rates of children and younger adults in a more extensive way than using just child mortality rates. Net reproduction rate (Espenshade et al. 2003) should replace the current formula as soon as data make it feasible. Additional theory might be used to better inform the slopes of the indicator adjustments, and to benchmark the optimum figure.

In addition, the 1.8 target used currently is not a fair target for countries early in demographic transition. For these, it may be possible to use a more complex formula that compares current and predicted adjusted fertility rates in order to compensate for this.

Social Indicator: GDP-adjusted child mortality

Metric	0	100	Equation	Time period	Source
% difference between actual child mortality and predicted child mortality	≥50%	≤-50%	$100\left(\frac{x-50}{-50-50}\right)$ [See Figure 12 for equation used to predict values]	5-year average (2008-2012)	UN Inter-agency Group for Child Mortality Estimation, (2015)

Table 9: Equation, definition and data source for child mortality indicator

<u>The indicator</u>

This indicator examines child (under-5) mortality. In order to correct for GDP, for each year a power regression was calculated (Figure 12) which was used to estimate what child mortality "should" be based on a country's per-capita income. Observed child mortality was expressed as a percentage of this, and entered into the equation above. The upper and lower benchmarks were chosen based on the data range, and for explanatory power: a score of 50 is equivalent to matching the predicted mortality rate, and every point of difference from that is a % distance from that rate (i.e. a score of 75 implies a country is 25% below the predicted mortality rate).

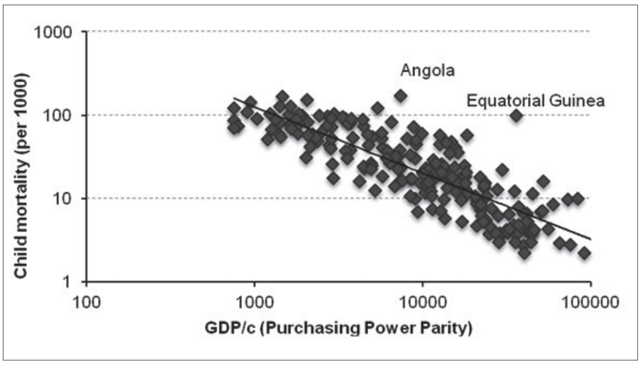

Figure 12: Log-log relationship between child mortality and GDP/c in 2012, with regression best fit: r^2=0.70 p<0.01, y = 30482$x^{-0.79}$

<u>Theoretical basis</u>

Health is one the main forms of human capital that are passed on between generations, and child mortality is used here as an indicator of the health component of the next generation's human capital. It is also widely regarded as one of the best indicators of current national health status (Wang 2002). However, GDP is a significant direct and indirect causal variable (O'Hare et al. 2013); of the years 2008-2012 it predicted an average of 74.9% of variance in child mortality (log-log, see Figure 12 for 2012's regression). As this index measures intergenerational solidarity proportional to ability to give, it seems reasonable to control for GDP per capita. To illustrate, Iceland has one of the lowest child mortality rates in the world, declining from 2.7 to 2.2 per 1,000 over 2008-12. Based on the regression of all countries, and given its GDP of $44 200, we might expect it to have a 2012 child mortality rate of 5.3; it is doing more than twice as well as might be expected, and therefore receives 100 in the index. Other countries with similar ratios are Cuba, South Korea and Eritrea; while Eritrea has a 2012 child mortality rate of 51.6 per 1000, it is so poor that this is around half its expected rate, and its high score in the indicator seems justified given its comparatively successful campaigns against malaria (Mufunde et al. 2007) and maternal mortality (Holzgreve et al. 2012).

Health is one the main forms of human capital that are passed on between generations and child mortality is used here as an indicator of the health component of the next generation's human capital.

There seem to be several causal pathways to decreasing child mortality, and disagreement about which are most important in which contexts. However, in developing nations a considerable amount of the variance seems to be driven by female education (Filmer/Pritchett 1999; Gakidou et al. 2010) – another form of intergenerational capital transfer which this indicator may be a proxy for.

<u>Future directions</u>

This indicator is fundamentally related to the annual derivation of the relationship between GDP and child mortality. If the relationship between these variables becomes less significant or precise, then the indicator method should be changed to reflect this.

Results

Map of results

Figure 13: Choropleth map of index score

Distribution of countries

The full table of results for the index can be seen in Online Appendix II (see igjr.org). In total, 120 countries covering 92.4% of the world's population were included. Most countries were in the middle of the range, with the median being 42 and the mean being 40. Norway was the best performing country by some way (78 vs. 70 for the next highest, Costa Rica), and Mongolia took bottom place with 10. Table 10 shows some cultural divisions of particular note. Within these groups, there are some outliers of note. In the OECD, Turkey, Greece and Portugal are on 32 and 33, while the USA does only marginally better on 40. In Latin America, Nicaragua trails on 24, behind next-placed Paraguay on 36, but Costa Rica comes second in the world on 70, 10 points ahead of Peru.
It is important to note that these categories exclude countries with insufficient data. These tended to be very small countries, those below the Sahara, and those in the Middle East.

Group	Mean	Range
Countries with constitutional reference to future generations:	42	65
Communist/Post-Communist:	47	58
Nordic Countries:	61	28
Anglosphere:	53	24
Latin America:	47	46
Sub-Sahara:	21	24
Oil-Producers:	39	63
OECD:	54	46
Confucian:	63	11

Table 10: Selected mean index scores and ranges of different groups of countries. See supplementary material for a list of countries in each grouping

Discussion

How useful is the index?

After compiling an index, it is important to sense-check it. Does it say anything useful? Does it react well to different data inputs? This section summarises some of the indications that it works well.

Geometric aggregation

The use of geometric aggregation has allowed the index to react well to extremes of poor performance, even in only one dimension. For example, regarding low performance in one field, Paraguay has middling economic and slightly below-average social components, and its carbon footprint and renewable energy use are among the best in the world. However, given it has the worst forest degradation rate in the world (an astonishing 16.8%), its final score of 32 is much lower than it might otherwise be – if it had even the same degradation rate as Brazil, its final score would have jumped to 50.

Correlations

All indicators except wealth inequality correlated with the final outcome (see supplementary material online at igjr.org). The standard deviation for wealth inequality was low (10.9) even after a square transformation, which is likely to be one reason for this. This does not necessarily suggest that it should be excluded, given that it did change countries' relative scores with each other. Indeed, it may come to be of more discriminative use in the future as wealth inequality in many countries is rising (Stierli et al. 2014).

One of features of a good index is that it is interesting, i.e. it differentiates superficially similar countries and provides a good explanation for that. For example, it may be surprising that the USA's score of 40 is so low compared to similar countries in the OECD; however, this can be traced partly to high inequality and carbon footprints, low savings rates and very poor child mortality given its GDP per capita.

Carbon footprint correlates negatively, but this is mostly driven by poor, low-footprint countries and it affects the rankings of better-scoring countries in a highly heterogeneous way. It is worth noting that five of the top 10 scoring countries had footprints of 0.8 Gha/c or below.

Differentiation

One of features of a good index is that it is interesting, i.e. it differentiates superficially similar countries and provides a good explanation for that. For example, it may be surprising that the USA's score of 40 is so low compared to similar countries in the OECD (Table 10); however, this can be traced partly to high inequality and carbon footprints, low savings rates and very poor child mortality given its GDP per capita. Thus, the USA can be said to generally act less in the interests of future generations than other similar countries, something that is not necessarily apparent from individual indicators.
Another example is that despite their generally high scores, the three Scandinavian countries are further spread than might be expected for such culturally, linguistically and economically homogenous countries. The root causes can be traced to varying investments in renewable energy, savings, and differing inequality. Interestingly, forest degradation appears highest in Sweden, despite having by far the most forest area per capita. Iceland, which shares many cultural features, fares the worst of all Nordic countries despite very good environmental and social scores. This is entirely caused by its recent history of economic mismanagement and consequential current account and savings problems.

Patterns of note

High and low performers

The highest scores are generally driven by good performance in all of the social indicators, healthy current account balances and high savings (see supplementary material), while environmental indicators are not much above the median aside from low-carbon energy generation (+20). Amongst low scorers, the differences seem to be driven by forest degradation (the bottom deciles are on average -34 points from the median), balances of payments (-45 points), pupil-teacher ratios (-45 points), and fertility rates (-31 points).

Cultures and groupings

In dividing up the world into some social and economic groupings (Table 10), some patterns can be discerned. Despite the top 10 containing three post-communist countries, one communist country (Vietnam; China is 11th) and two Nordic social democracies, countries with socialist or communist heritage have a wide range of scores and this group also contains the overall lowest country (Mongolia). Further research might investigate the particulars of the legacy of socialist planning on their levels of intergenerational solidarity; it may be that certain countries have retained the kind of long-term orientation that supposedly characterised planned economies (Ellman 2014). The Nordic social democracies all score above average, but the four Confucian nations included do even better; some researchers have proposed that long-termism is an inherent part of Confucian culture (e.g. Hofstede 1993) and this gives some evidence to this suggestion. In an interesting contrast, it appears that reference in a nation's constitution to future generations is irrelevant to actual actions – these countries perform no better than others on average. Also, the large oil incomes that fund some nations' sovereign wealth investment funds – Norway and Saudi Arabia, for instance – do not appear to have a universal effect on intergenerational solidarity, with the average score of major oil producers similar to the average of all countries.

The Nordic social democracies all score above average, but the four Confucian nations included do even better; some researchers have proposed that long-termism is an inherent part of Confucian culture (e.g. Hofstede 1993) and this gives some evidence to this suggestion.

Correlates

There are some interesting relationships with national variables of population density, population and GDP (PPP) per capita[19]. It seems that there is relatively little relationship with density or population, thus casting doubt on the idea that intergenerational solidarity may be something that is particularly easy for sparsely-populated or small countries. However, despite attempting to measure proportionality and thus expressing a preference for indicators that were not purely proxies for income, GDP/c does have a large and significant relationship with several indicators and a medium relationship with the overall index. There may also be a causative relationship in either direction, i.e. that rich countries can give proportionally more to future generations or that long-termist countries end up with higher incomes. Rawls suggests that this is the case:

> *"When people are poor and saving is difficult, a lower rate of saving should be required; whereas in a wealthier society greater savings may reasonably be expected since the real burden of saving is less."* (Rawls 1999: 255)

However, the correlation does only predict 22% of variance and there are many outliers; it is quite likely that much of the effect comes from the generally poor performance of Sub-Saharan African countries suffering from well-documented complexes of socioeconomic and institutional problems. It should also be noted that within the top decile of nations, there is a very wide range of per-capita income, from $694 in Nepal and $3279 in Sri Lanka to over $100,000 in Norway.

Suggestions for refinements and future research

Rawls asserts

> "*Each passes on to the next a fair equivalent in real capital as defined by a just savings principle… capital is not only factories and machines, and so on, but also the knowledge and culture, as well as the techniques and skills, that make possible just institutions and the fair value of liberty.*" (Rawls 1999: 256)

This index could not capture the kinds of capital he mentions, except through a measure of each nation's investment in primary education. Further consideration should be given to these as the coverage and quality of measurement of social capital improves. As datasets become available, indicators from other dimensions should be added to the index, whilst retaining the ratio between different dimensions. Of those mentioned in Online Appendix I (see igjr.org), the social discount rate should be one of the main priorities for further research. Theory-based predictors of personal discount rates should also receive attention.

It appears that reference in a nation's constitution to future generations is irrelevant to actual actions – these countries perform no better than others on average.

Weighting is an area of contention in index-building. While this index has *a priori* equal weighting, *a posteriori* contributions from each indicator could be calibrated through the use of structural equation modelling or similar, although dimensions should remain equally-weighted. Also, more GDP-corrections might be considered for a number of the indicators; as this index is conceived as a comparative tool between cultures rather than a direct measure, this would help adjust for ability to give. Poor nations that give more than would be expected to their future generations are at least as important to study as those more able to give, if not more so.

Further editions of the index might also take into account cross-cultural surveys about our attitudes and behaviour towards the future, for example the Consideration of Future Consequences Scale (Strathman et al. 1994) or the Zimbardo Time Perspective Inventory (Zimbardo/Boyd 1999). An interesting project in itself would be to see if future orientation by either of these measures correlates with the results of this index. Similarly interesting would be further research into the reasons for high index scores, particularly as to whether "Confucianism" can really explain why Korea, Japan, China and Vietnam score so highly.
Greater statistical analysis (e.g. factor analysis, sensitivity analysis) could be performed on the index in order to better select variables and in particular to adjust the transformations and processing of indicator data to ensure equal weighting. It would be of benefit to do this after review from academics in relevant fields, to better determine subjective impressions of the indicator results. In the first iterations of the index, equal weighting is justified by a lack of

information, but as we better define the constituents of intergenerational solidarity and assess the ability of indicators to measure this, weighting may be used.

Lastly, the index could be calculated regularly to give time-series data. Historical data are also available for all indicators except pupil-teacher ratio and forest degradation, but each year back in time includes fewer countries. It seems promising that both of these factors will be measured with greater accuracy in the future.

Conclusion

This index is a coherent attempt to construct a theory-based multidimensional composite measure of intergenerational solidarity, the yardstick for intergenerational justice. As a starting point, it is still far from being precise or accurate, but in this regard it suffers from the same limitations as all composite indexes, and accounts for many of the problems in others.

Despite its limitations, the usefulness of a composite figure is shown in revealing interesting patterns of nations, for example that high income does not necessarily guarantee proportionally high levels of intergenerational solidarity, that constitutional reference to future generations is largely irrelevant to action in their interests, and that countries with a Confucian heritage do seem to act more in the interests of future generations. Where it may be most useful is in the decomposition of national scores to look for plausible reasons behind a lack of intergenerational solidarity. As it stands, this index can assist further research into the causes of intergenerational solidarity and lends itself to refinement by other scholars.

The task of understanding and prioritising intergenerational solidarity may seem daunting, but we live in a world that is testament to the long-term plans and actions of our ancestors. This index was conceived in an oak-coppice forest in Wales where cover trees have been planted in 150 year rotations for at least the last millennium. If medieval charcoal-burners and foresters – some of the poorest classes of their time – were able to be so magnanimous, then there is hope for the societies of our own time.

Notes

1 I would like to thank Brynhildur Daviðsdóttir and Þröstur Þorsteinsson for their comments on an earlier version of this paper, and Beth Stratford and Bec Sanderson for their intellectual solidarity. I would also like to thank the forestry workers of Coppicewood College in Wales for keeping our heritage of intergenerational solidarity alive and, in doing so, inspiring this project.

2 This is used throughout as ">50 years" following the definition of "intergenerational discounting" set out by Moore et al. (2004).

3 See section "Conceptional framework" for a definition.

4 "Discounting the future" refers to the extent to which we prefer present over future value. The "discount rate" is an economic term used to define the net present value of future stocks and flows of capital. It has a vital role in determining investment in future generations, but see section "Economic Indicators".

5 This conceptualisation is close to "sustainable development", i.e. "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987: 41). However, Stiglitz et al. note (2009: 72) that measures of sustainable development often "effectively conflate the measurement of current wellbeing and the measurement of its sustainability". This index is focused only on the future, specifically on investments in future wellbeing (i.e. beyond basic needs). This is meant to encompass all parts of society, not just government investments.

6 And sometimes explicit – more than 40 nations reference obligations to future generations in their constitutions (Boyd 2011: 311).

7 As with the "strong" version of the sustainability concept.

8 This is not to say that they are vague, however – for example, the capacity of societies to transform might be related to evidence-based policy decisions, capture of government by special interests, path dependency in infrastructure choice etc. Aggregating this would clearly be difficult, but the area deserves qualitative commentary.

9 see Online Appendix I (see igjr.org).

10 All null values were aggregated using a value of 1, as is necessary for geometric aggregation to function.

11 Equations are unsimplified for explanatory clarity. Here, -10 is the scale minimum, and 0 is the maximum.

12 Assuming e.g. a linear relationship between GDP and carbon footprint.

13 For Malawi, Uganda, Madagascar, Laos, Paraguay, Niger, Burkina Faso, Mali, Rwanda, Guinea, Burundi, Liberia.

14 Some classic examples of national economic crises predicted by a large current account deficit are: the 1991 Indian crisis; the 1997 Asian crisis (Radelet/Sachs 1998); the 2008 Icelandic crisis (Obstfeld 2012); the 1999-2002 Argentinian crisis (Bussière 2007); the 1994 Mexican crisis (Blecker/Ibarra 2013); and arguably the ongoing crisis in much of the Eurozone (Krugman 2014), or even the 2008 global financial crisis (Corden 2011).

15 There is considerable discussion of the relationship between current account deficits and post-2008 GDP, e.g. see Backus et al. (2005); Blanchard (2007); Blanchard/Milesi-Ferretti (2012); Brissimis et al. (2012); Herwartz/Siedenburg (2007); Milesi-Ferretti et al. (1996); Radelet/Sachs (1998).

16 Vemuri and Costanza (2006) could find no measure of social capital that adequately related even to current wellbeing, and Glaeser et al. (2004) found no necessary relationship between institutional quality (a common measure of social capital), growth and poverty-reduction, and considered most measures of institutional quality to be "conceptually unsuitable" for measuring what they purported.

17 It is common for indicators of educational capital in composite indexes to use spending on education or years of schooling as an indicator. However, years of primary schooling do not vary meaningfully outside of the least developed countries, and the number of teaching staff probably has a closer relationship with education outcomes than spending more generally (Glewwe et al. 2013).

18 i.e. impact is a function of population, affluence and technology.

19 See supplementary material.

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Online Appendix

Appendix I – Descriptive Statistics

	Mean of top decile	Mean	Median	Mean of bottom decile	Range
Forest Degradation	81	72	76	41	100
Carbon Footprint	60	67	75	81	93
Low-Carbon Energy	43	28	25	19	100
Environmental Average	55	43	44	31	85
Wealth Inequality	52	47	49	54	64
Current Account	90	64	74	26	100
Adjusted Net Savings	69	42	34	14	100
Economic Average	67	42	45	18	79
Pupil-Teacher Ratio	81	62	74	25	100
Child Mortality	86	57	66	32	100
Fertility Rate	82	57	64	29	91
Social Average	83	52	57	15	94
Index	67	40	41	13	68

Descriptive statistics of indicators and index. Deciles are determined based on final index score, not indicator score

	Mean	Range
Countries with constitutional reference to future generations: Uganda; Burundi; Malawi; Jamaica; Qatar; Zambia; Ghana; South Africa; Portugal; Lesotho; Kenya; Albania; Armenia; Argentina; Bolivia; Poland; Morocco; Namibia; Brazil; Ecuador; Russian Federation; Czech Republic; Venezuela; Switzerland; France; Germany; Tajikistan; Sweden; Norway[1]	42	65
Communist/Post-Communist: Azerbaijan; Lithuania; Vietnam; Tajikistan; Latvia; China; Russian Federation; Estonia; Ukraine; Armenia; Kyrgyz Republic; Belarus; Kazakhstan; Mongolia; Poland; Slovakia; Romania; Bulgaria; Hungary; Czech Republic; Albania; Macedonia; Croatia; Slovenia, Lao, Cambodia	47	58
Nordic Countries: Sweden, Norway, Denmark, Finland, Iceland	61	28
Anglosphere: UK; USA; New Zealand, Australia, Canada, Ireland	53	24
Latin America: Costa Rica; Venezuela, RB; Peru; Ecuador; Brazil; Uruguay; Bolivia; Colombia; Argentina; Chile; Panamas; Paraguay; Nicaragua	47	46
Sub-Sahara: Mauritius; Kenya; Namibia; Senegal; Burkina Faso; Rwanda; Ethiopia; Congo, Dem. Rep.; Lesotho; Togo; Nigeria; Liberia;	21	24

Botswana; South Africa; Ghana; Sudan; Cameroon; Tanzania; Cote d'Ivoire; Malawi; Guinea; Zambia; Angola; Benin; Mali; Burundi; Niger; Uganda; Sierra Leone; Mozambique; Guinea-Bissau		
Oil-Producers[2]: Norway; Azerbaijan; Venezuela; Canada; Russian Federation; Denmark; Ecuador; Mexico; Australia; Algeria; Malaysia; Colombia; Nigeria; USA; Kazkhstan; Saudi Arabia; Angola; Kuwait	39	63
OECD: USA; Greece; Portugal; Chile; Israel; Poland; Turkey; Australia; Mexico; Slovakia; Estonia; Netherlands; Ireland; Spain; South Korea; Denmark; Italy; United Kingdom; Canada; Czech Republic; Japan; Switzerland; New Zealand; France; Austria; Finland; Germany; Belgium; Hungary; Slovenia; Norway; Iceland	54	46
Confucian: Vietnam; China; Japan; South Korea	63	11

Selected mean index scores and ranges of different groups of countries

	Forest Degradation	Carbon Footprint	Low-Carbon Energy	Environmental Average	Wealth Inequality	Current Account Balance	Adjusted Net Savings	Economic Average	Pupil-Teacher Ratio	Child Mortality	Fertility	Social Average	Index Average
Forest	1	-.229*	-0.069	.201*	0.003	0.016	0.068	0.111	.236*	0.075	.212*	.204*	.263**
Footprint	-.229*	1	0.02	.421**	0.173	-.434**	-.220*	-.375**	-.781**	-0.164	-.574**	-.516**	-.282**
Energy	-0.069	0.02	1	.747**	0.01	-0.037	-0.086	-0.054	0.075	.187*	0.152	.207*	.433**
Env. Average	.201*	.421**	.747**	1	0.06	-.201*	-0.144	-0.156	-.227*	0.032	-0.034	-0.029	.309**
Inequality	0.003	0.173	0.01	0.06	1	-.273**	-.228*	-0.158	-.196*	0.174	-.192*	-0.056	-0.141
BoP	0.016	-.434**	-0.037	-.201*	-.273**	1	.376**	.768**	.467**	-0.029	.374**	.270**	.472**
Savings	0.068	-.220*	-0.086	-0.144	-.228*	.376**	1	.779**	.267**	0.118	.305**	.262**	.490**
Econ. Average	0.111	-.375**	-0.054	-0.156	-0.158	.768**	.779**	1	.426**	0.098	.406**	.342**	.645**
Teachers	.236*	-.781**	0.075	-.227*	-.196*	.467**	.267**	.426**	1	.268**	.688**	.733**	.513**
Child Mortality	0.075	-0.164	.187*	0.032	0.174	-0.029	0.118	0.098	.268**	1	.275**	.711**	.466**
Fertility	.212*	-.574**	0.152	-0.034	-.192*	.374**	.305**	.406**	.688**	.275**	1	.725**	.588**
Social Average	.204*	-.516**	.207*	-0.029	-0.056	.270**	.262**	.342**	.733**	.711**	.725**	1	.724**
Index Average	.263**	-.282**	.433**	.309**	-0.141	.472**	.490**	.645**	.513**	.466**	.588**	.724**	1
Population	0.026	.185*	-0.023	0.102	-.190*	0.135	0.048	0.122	-.233*	-0.113	-0.119	-.191*	0.114
GDP/c (2013)	.234*	-.860**	0.119	-.236**	-.314**	.552**	.274**	.471**	.864**	0.115	.702**	.603**	.466**
Density (2013)	0.142	-0.152	-0.082	-0.032	0.05	0.062	.209*	.216*	0.045	.293**	0.108	0.153	0.149

**p<.05 (two-tailed); **p<.01.*

Bivariate correlations (Spearman's ρ) of indicators, averages and selected variables

Appendix II – Some indicators considered for inclusion

Indicator	Source	Reason for rejection
Maternity leave laws[3]	ILO	Despite being used elsewhere, there is little evidence linking this to the wellbeing of children, as opposed to parents.
Education spend (%GDP/c) per primary student	UNESCO	Not enough data points
School Attendance	UNESCO	Not enough differentiation in rich countries; statistics heavily skewed by repeat years, late entry etc.
Life Expectancy	World Bank	Not enough differentiation in rich countries; theoretically lacking as it describes current human capital rather than the next generation's.
Funding for health care as % of GDP/c	Various	Lack of centralised data on public/private spending splits; theoretically may relate exclusively to disproportionate investment in current generations e.g. healthcare for the elderly
State spending on the old vs. the young[4]	Various	Not enough data; may relate more to differences in pension funding mechanisms
Deforestation rate	FAO	Unreliable; superseded by satellite data
Consumption CO_2 per capita	Footprint of Nations	Not enough data points
Gross Capital formation	World Bank	Not as precise as Adjusted Net Savings
Gross Savings	World Bank	Not as precise as Adjusted Net Savings
Central Government Debt	World Bank	Not an indicator of short-termism (see Economics section) and non-comparable between federal and non-federal countries
Income Inequality (Gini)	World Bank	Wealth inequality more relevant
Research & Development Budget	World Bank	Non-comparable data due to differences in public/private investment
Advertising to Children	Various	Not enough data points
Social Discount Rate	Various	Not enough data points
Personal Discount Rate	Various	Currently too heterogeneous in measurement[5]
Household Debt	Various	Not enough data points

Pension spending/deficit by central government	Various	Non-comparable data due to differences in public/private investment; not enough data points
United Nations Voluntary Contributions (%GDP/c)	U.N.	Inadequate data; U.N. funding is generally progressive (even after corrections for GDP)
Child Wellbeing	UNICEF	Not enough data points
Status of tobacco	Various	Too much variation in policies
Soil erosion/land degradation	FAO	Not enough time-series data points (1991 only); doubts about accuracy; much reflects semi-natural change (e.g. desertification)

Appendix III – Full table of indicator and index scores

	Forest Degradation	**Carbon Footprint**	**Low-Carbon Energy**	**Environmental Average**	**Inequality**	**Current Account Balance**	**Adjusted Net Savings**	**Economic Average**	**Pupil-Teacher Ratio**	**Child Mortality**	**Fertility**	**Social Average**	**Index Average**	**Rank**
Norway	82	75	61	72	39	100	88	70	100	83	96	93	78	1
Costa Rica	68	86	59	70	41	58	75	56	76	91	91	86	70	2
Vietnam	64	100	21	51	57	100	76	76	73	82	86	80	68	3
Slovenia	90	23	51	47	71	100	54	73	85	100	82	89	67	4
Sweden	59	22	67	44	37	100	91	70	100	100	88	96	67	5
Nepal	96	100	16	54	53	100	100	81	38	88	82	65	66	6
Lithuania	73	46	43	52	55	100	36	58	91	90	89	90	65	7
France	86	30	68	56	51	85	46	59	79	92	81	84	65	8
Hungary	100	43	40	56	58	100	37	60	99	89	61	81	65	9
Sri Lanka	83	100	20	55	55	58	92	67	66	100	59	73	64	10
China	75	50	19	42	48	100	100	78	80	77	87	81	64	11
New Zealand	100	50	54	65	50	70	36	50	86	72	86	81	64	12
Switzerland	92	18	63	47	36	100	87	68	98	67	74	78	63	13
Belgium	73	21	46	41	60	93	50	66	97	83	98	92	63	14
Korea, Rep.	83	22	41	42	45	100	100	77	64	100	57	72	61	15
Bulgaria	99	40	48	58	56	82	37	55	83	62	76	73	61	16
Tajikistan		100	76	87	60	60	41	53	68	74	23	49	61	17
Germany	81	26	36	42	41	100	64	64	92	87	65	80	60	18
Peru	82	100	32	64	33	74	66	55	72	54	60	61	60	19
Philippines	81	100	49	74	30	100	100	67	40	50	40	43	60	20
Finland	54	17	45	34	49	100	52	63	88	100	96	95	59	21

Spain	90	32	40	49	55	74	34	52	92	91	57	78	58	22
Croatia	96	35	24	43	56	88	29	52	86	100	75	86	58	23
Austria	68	21	33	36	39	100	71	65	95	82	68	81	58	24
Netherlands	83	26	14	31	47	100	66	68	96	76	96	89	57	25
Latvia	33	55	25	35	54	100	56	67	95	72	68	78	57	26
Japan	94	25	38	45	60	100	21	50	79	100	69	82	57	27
Uruguay	100	86	38	69	40	66	18	36	81	60	81	73	57	28
Ireland	100	19	15	30	49	100	60	67	83	83	83	83	55	29
El Salvador	50	100	58	66	47	59	34	45	29	81	73	56	55	30
Czech Republic	90	23	41	44	40	77	28	45	81	100	72	83	55	31
United Kingdom	89	25	30	40	53	72	26	46	81	77	90	82	54	32
Romania	90	60	34	57	46	63	25	41	83	45	74	65	54	33
Italy	94	29	24	40	56	85	18	44	99	97	66	85	53	34
Ecuador	78	100	27	59	43	92	32	51	73	33	55	51	53	35
Brazil	52	100	39	59	32	76	23	38	70	46	92	67	53	36
Denmark	66	30	19	34	21	100	58	49	98	88	82	89	53	37
Thailand	75	75	8	35	32	100	70	61	83	64	64	70	53	38
Canada	63	18	47	38	47	68	41	51	85	66	76	75	52	39
Venezuela, RB	83	43	32	49	33	100	54	56	78	29	61	52	52	40
Macedonia, FYR	75	30	21	36	52	68	31	48	80	97	67	81	52	41
Estonia	48	35	6	22	53	100	66	71	96	100	70	88	51	42
Malaysia	28	55	9	24	35	100	85	67	87	77	90	84	51	43
Australia	100	25	12	31	59	60	36	51	86	79	88	84	51	44
Indonesia	45	100	28	51	29	94	100	65	79	12	65	40	51	45
Russian Federation	84	25	29	39	20	100	51	46	81	42	86	66	49	46
Iceland		75	91	82	53	82	0	16	100	100	72	90	49	47
Ukraine	82	50	43	56	16	45	22	25	83	100	69	83	49	48
Mexico	68	32	25	38	42	88	51	57	55	36	74	52	48	49
Bangladesh	72	100	5	32	54	100	100	81	14	70	80	42	48	50
Poland	95	32	6	26	44	62	45	50	99	98	64	85	48	51
Israel		26	21	24	40	100	70	65	92	98	36	69	47	52
Slovak Republic	70	33	50	49	80	90	4	30	84	68	66	72	47	53
Morocco	100	100	11	48	38	29	100	48	58	32	40	42	46	54
Colombia	76	100	35	65	41	72	5	25	55	52	67	57	45	55
Armenia	98	100	56	82	59	0	38	13	75	84	92	83	45	56
Argentina	10	86	25	27	35	100	30	47	84	44	72	64	44	57
Cyprus	84	26	16	33	35	35	17	28	86	100	69	84	42	58
Chile	100	100	25	63	38	91	0	15	62	80	97	78	42	59
Bolivia	54	100	18	46	44	100	20	45	65	18	36	35	41	60
Azerbaijan	96	86	14	48	58	100	57	69	94	0	95	21	41	61
United States	59	14	34	30	28	72	29	39	90	20	91	55	40	62
Tunisia	100	100	4	33	45	37	12	27	79	62	64	68	39	63
Egypt, Arab Rep.		100	13	37	35	78	18	37	62	30	46	44	39	64
Albania	64	100	45	66	55	0	26	11	75	72	92	79	39	65
Kyrgyz Republic	97	100	60	83	58	0	25	11	64	95	29	56	38	66
Paraguay	0	100	100	22	43	100	18	43	60	62	44	55	37	67
Haiti	73	100	7	38	41	61	68	55	10	39	35	24	37	68
Panama	59	60	32	48	39	5	100	27	65	14	58	37	36	69

Mauritius	100	43	29	50	45	3	31	15	71	44	61	57	35	70
Kenya	61	100	27	55	50	30	33	37	16	20	20	19	34	71
India	84	100	16	51	34	68	95	60	29	0	62	12	33	72
Portugal	45	32	27	34	50	42	0	13	97	100	64	85	33	73
Pakistan	89	100	20	56	61	86	48	63	27	0	41	10	33	74
Senegal		100	8	28	55	36	45	45	32	52	15	29	33	75
Jordan		75	13	31	56	4	54	24	75	40	34	47	33	76
Greece	72	27	17	32	54	34	0	12	97	96	70	87	32	77
Namibia		100	29	54	31	64	65	51	45	0	41	12	32	78
Turkey	93	55	24	49	29	36	40	35	75	0	84	18	32	79
Algeria	76	100	3	27	54	100	100	82	64	0	40	14	31	80
Belarus	97	35	1	16	58	1	96	18	86	100	93	93	29	81
Burkina Faso		100	21	46	55	67	34	50	4	28	13	11	29	82
Rwanda	90	100	27	62	48	19	30	30	0	88	19	12	28	83
Congo, Dem. Rep.	76	100	17	51	53	32	0	12	32	73	12	31	26	84
Ethiopia	84	100	11	45	61	56	11	34	0	86	20	12	26	85
Lao PDR	57	100	93	81	59	78	0	17	51	0	44	13	26	86
Togo	78	100	6	35	57	41	0	13	27	62	18	31	24	87
Lesotho		100	74	86	46	0	73	15	30	0	45	11	24	88
Bahrain		11	0	3	56	100	58	69	95	32	83	63	24	89
Nicaragua	0	100	32	15	49	0	66	15	44	86	58	60	24	90
Jamaica	66	75	7	33	41	0	28	6	60	70	69	66	23	91
Singapore		14	0	2	48	100	100	78	77	85	57	72	23	92
Nigeria	79	100	7	37	36	100	24	44	27	0	11	7	22	93
Liberia	69	100	0	19	57	0	31	12	58	100	17	46	22	94
Lebanon	98	38	11	34	26	0	0	3	89	76	69	77	20	95
Botswana		60	0	8	37	81	100	67	61	0	55	15	20	96
South Africa	100	38	16	39	33	61	1	14	47	0	63	14	20	97
Ghana	52	100	24	50	55	5	12	15	44	0	27	11	20	98
Sudan		100	14	37	59	39	4	20	42	0	21	10	19	99
Cameroon	89	100	23	59	54	63	4	24	6	0	18	5	19	100
Cote d'Ivoire	8	100	12	21	48	100	22	47	16	0	16	6	19	101
Malawi	21	100	71	53	55	0	21	11	0	99	13	11	18	102
Kazakhstan	98	22	10	28	24	100	0	13	83	0	50	16	18	103
Tanzania	60	100	11	40	58	0	67	16	0	60	13	9	18	104
Guinea	64	100	46	66	56	0	0	4	14	46	17	23	18	105
Saudi Arabia		25	0	5	40	100	66	64	97	0	53	17	18	106
Angola	76	100	15	49	43	100	0	16	17	0	14	6	17	107
Qatar		8	0	3	47	100	100	78	97	0	91	21	17	108
Benin		100	0	10	56	18	23	28	6	37	17	16	16	109
Mali		100	51	71	56	13	21	25	0	0	9	2	15	110
Cambodia	0	100	3	7	55	42	17	34	0	76	45	15	15	111
Kuwait		8	0	3	44	100	67	67	100	0	49	17	15	112
Trinidad & Tobago	65	9	0	8	49	100	0	17	82	0	95	20	14	113
Burundi	72	100	51	72	59	0	0	4	0	92	11	10	14	114
Niger		100	0	10	56	0	31	12	24	64	7	22	14	115
Uganda	36	100	51	57	53	2	0	4	1	63	11	9	13	116
Sierra Leone	66	100	29	58	56	0	0	4	45	0	22	10	13	117

Mozambique	35	100	38	51	51	0	0	4	0	73	15	10	12	118
Guinea-Bissau	58	100	0	18	59	40	0	13	0	11	18	6	11	119
Mongolia	0	50	0	4	59	0	8	8	47	18	54	36	10	120

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Notes

[1] Boyd (2011): 311.

[2] >1000 litres per capita per year; CIA (2012).

[3] After Kasser (2011).

[4] After Vanhuysse (2013).

[5] Havranek et al. (2015).